Instruction Manual

TE-1971

SUBAUDIO MAGNETIC ANTENNA ET-1A/SML

MP MASTER
MA30063

ELECTRO INTERNATIONAL, INC.
ANNAPOLIS, MARYLAND

INSTRUCTION MANUAL
FOR
SUBAUDIO MAGNETIC ANTENNA

ET-1A/SML

Revised 1 July 1965

ELECTRO INTERNATIONAL, INC.
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Annapolis, Maryland

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Unauthorized modification of product.

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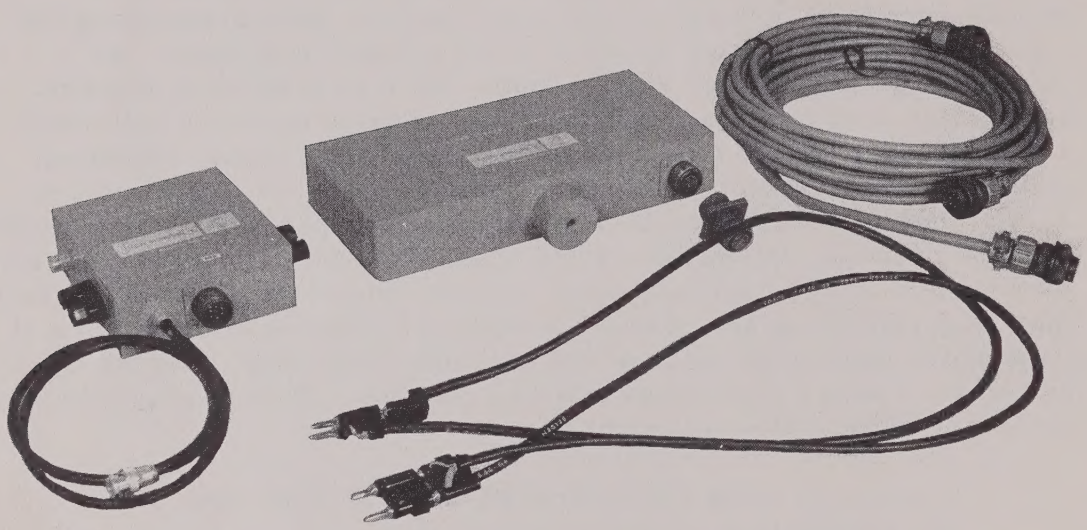

Figure 1–1. Subaudio Magnetic Loop Detection System; Loop Adapter (left) Magnetic Loop (center), and Cables

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SECTION 1 - GENERAL INFORMATION

1-1 APPLICATION

The ET-1A/SML Subaudio Magnetic Loop Antenna detects magnetic fields generated in various electrical and electronic equipment in the subaudio frequency range (3-45 cps). It is designed for use with the ET-1A/SA Subaudio Amplifier. Together, these equipments constitute the ET-1A Magnetic Field Intensity Detection System. Instructions for magnetic field intensity measurements will imply the use of the ET-1A/SA with the ET-1A/SML.

In general use the ET-1A/SML is used most effeciently in an area of low intensity ambient magnetic fields. Practically, this can be accomplished by situating the magnetic loop antenna of the ET-1A/SML inside a shielded enclosure together with the electronic equipment under evaluation. The measuring devices used in conjunction with the SML are then located outside the shielded enclosure.

1-2 DESCRIPTION

The ET-1A/SML, figure 1-1, consists of a sensitive magnetic loop antenna with an internal calibration winding, a calibration loop adapter, shielded interconnecting cables, external accessory cables, and a feedthru connector.

A. Magnetic Antenna Unit

Both the magnetic loop antenna and a calibration coil are permanently enclosed in a rectangular aluminum shield 10-1/4 inches by 1-3/4 inches

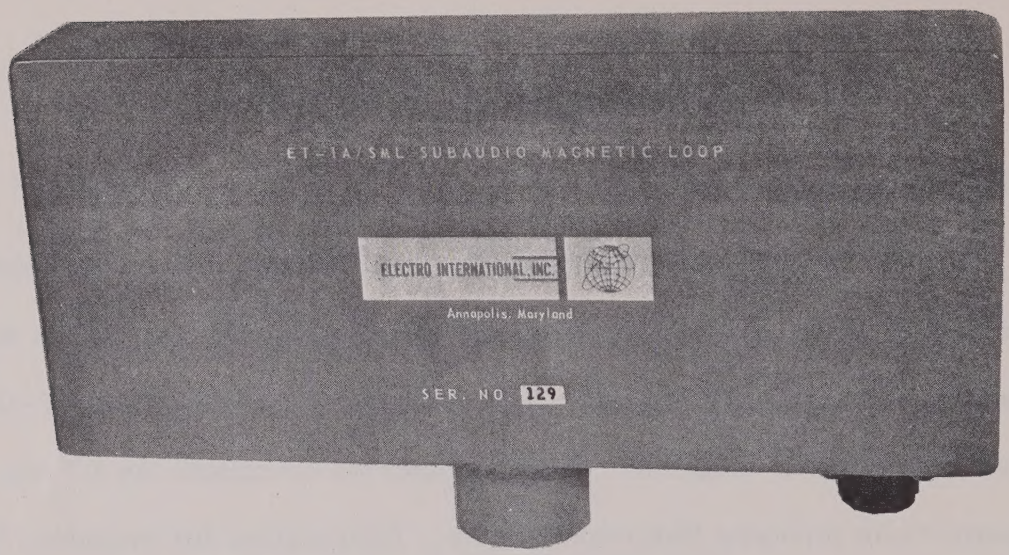


Figure 1–2. Antenna Unit.

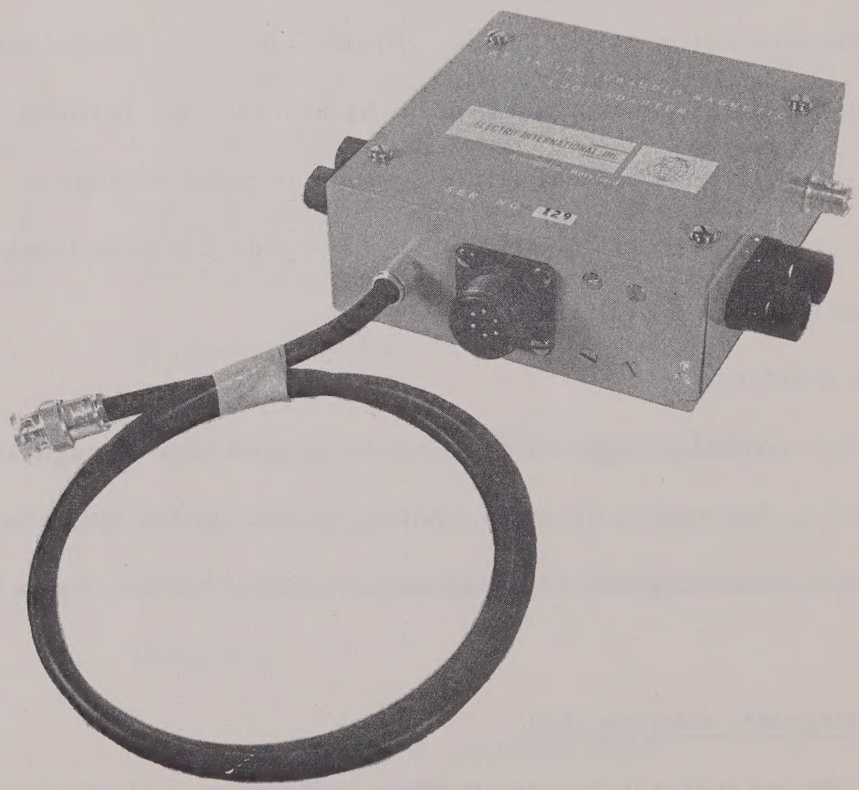


Figure 1–3. Adapter Unit.

by 4-1/2 inches to provide electric field shielding. The base of the antenna unit is threaded to permit stable mounting on a standard tripod. The ET-1A/SML Antenna unit is shown in figure 1-2.

B. ET-1A Subaudio Magnetic Loop Adapter

The ET-1A/SML Adapter, shown in figure 1-3, connects to the antenna unit. The signal from the antenna flows directly through the adapter to the Subaudio Amplifier. Both BNC and double banana jacks, (connected in parallel) on the SML Adapter provide a versatile external connection for an audio oscillator to excite the calibration coil and for a meter to measure the calibration voltage.

C. Interconnecting Cables

Two 15-foot lengths of 5-conductor shielded cable are supplied to facilitate interconnections between units. One cable provides connection between the antenna unit inside the shielded enclosure and the bulkhead feedthru. The other provides connection between the bulkhead feedthru and the SML Adapter outside the shielded enclosure (refer to figure 1-4).

D. Instrument Cables

Two 3-foot lengths of RG-59B/U coaxial cable with double banana plug connectors are supplied to connect an audio oscillator and a voltmeter to the SML Adapter. See figure 1-4.

E. Bulkhead Feedthru

One bulkhead feedthru (TB-14S-6PS) for the five-conductor cable is supplied. It is used when the Subaudio Magnetic Loop Antenna unit is

operated inside a shielded enclosure.

1-3 SPECIFICATIONS

Calibration:	Internal calibration winding permits calibration within ± 1 db, by signal substitution technique.
Output Impedance:	70 ohms
Frequency Range:	3-45 cps when used with ET-1A/SA Amplifier
Dimensions:	Magnetic Loop Antenna - 10-1/4 inches by 1-3/4 inches by 4-1/2 inches
Weight:	8 pounds

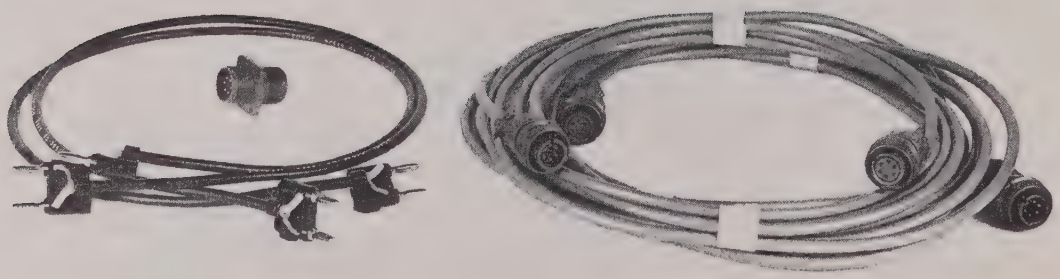


Figure 1-4. Interconnecting Assembly Cables And Instrument Cables.

SECTION 2 - PRINCIPLES OF OPERATION

2-1 GENERAL

The ET-1A Magnetic Field Intensity Detection System is designed to detect and measure magnetic fields of extremely low intensities in the subaudio frequency range of 3 to 45 cycles per second.

When the ET-1A/SML Magnetic Loop Antenna is placed in a time-variant magnetic field, an emf, proportional to (1) the rate of change of the field, and (2) the strength of this field, is induced in the antenna. The signal induced into the antenna must then be appropriately amplified. The ET-1A/SA Amplifier has the required characteristics to perform this function. This amplifier has a specially designed low-frequency input transformer with extended low-frequency response and multiple shielding against stray electric fields. The amplified signal is then observed on an oscilloscope.

The magnetic loop antenna is enclosed in an electric shield to guard against electric field pickup. The complete schematic circuit and interconnection diagram of the ET-1A/SML is shown in figure 2-1.

2-2 MEASUREMENT TECHNIQUE

The technique utilized to obtain quantitative values of the magnetic field intensity detected by the ET-1A/SML Magnetic Loop Antenna is the signal substitution method. A small calibration coil is installed within the antenna housing for this purpose. A known signal is applied to this coil so as to provide a response in the antenna equivalent to the detected magnetic

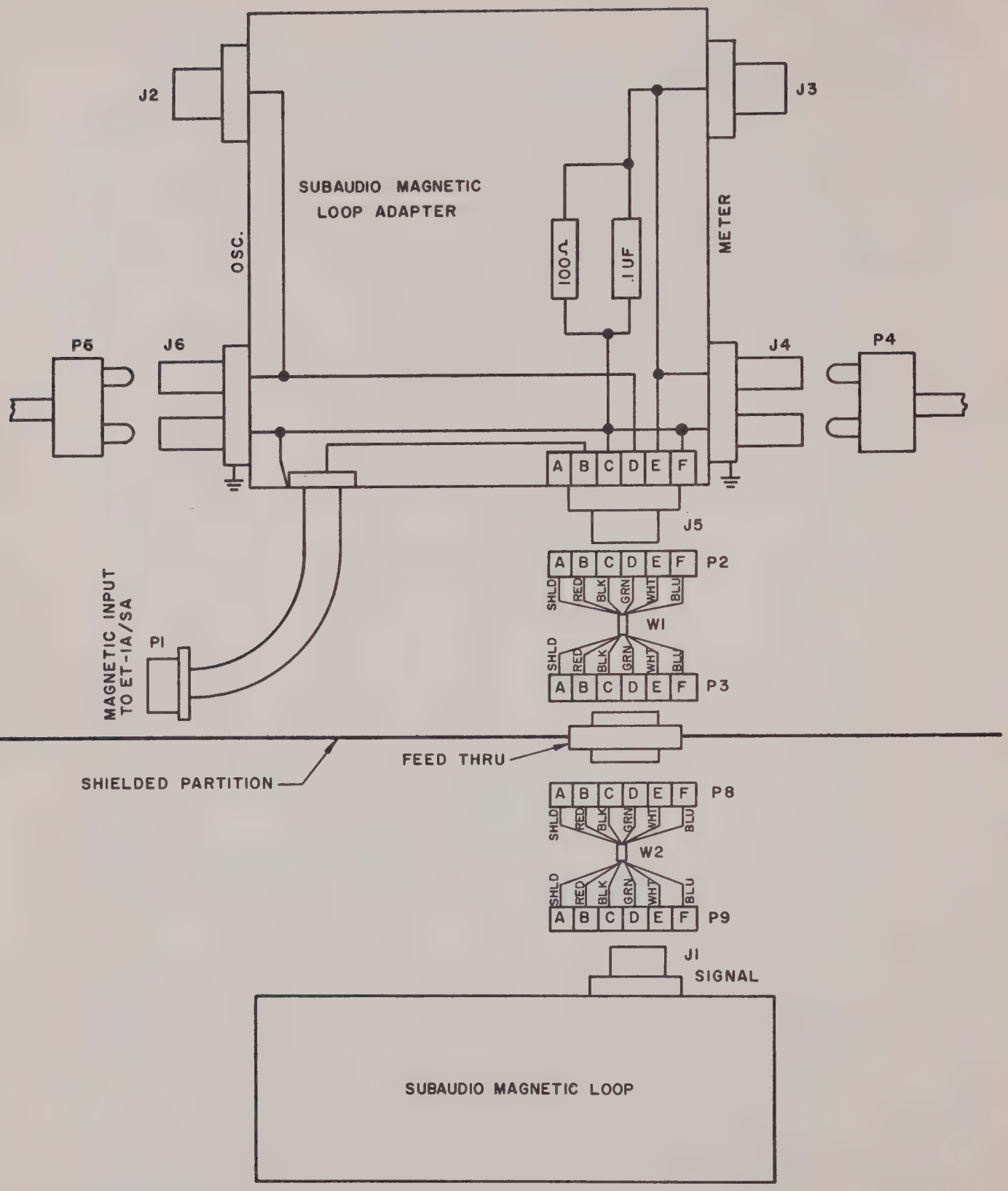


Figure 2-1. ET-1A/SML, Schematic and Interconnecting Diagram

field. From the characteristics of the applied magnetic field, the characteristics of the detected field are then determined.

To determine the applied field a calibration voltage is measured as a true rms voltage across a 100-ohm resistor which is located in the SML adapter, and is in series with the calibration coil. An empirically derived calibration factor, K, provides the means for obtaining the magnetic field intensity of the detected field from the known calibration voltage.

This relationship is given by

$$H = Vc + K$$

where H = Magnetic field intensity

V_C = Calibration Voltage

K = Calibration factor

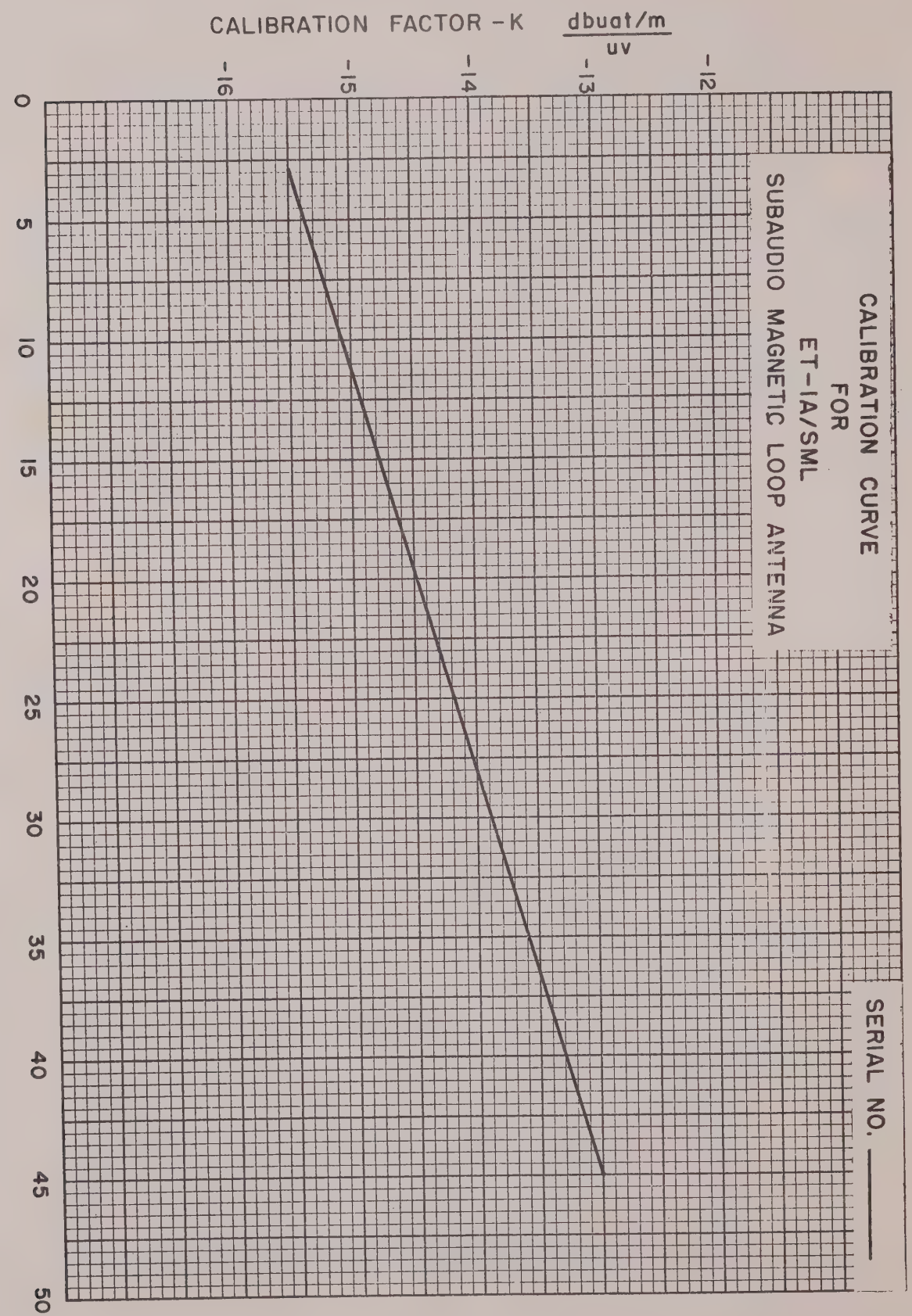
and the units are

H -- $db\mu at/m$ = db referenced to one microampere - turn per meter

V_C -- $db\mu v$ = db referenced to one microvolt

K -- $\frac{db\mu at/m}{\mu v}$ db referenced to one microampere - turn per meter per microvolt

The calibration factor, K, is not a constant, but is a function of the frequency of the magnetic field. Figure 2-2, the Calibration Curve, is a graph of the calibration factor vs. frequency.


CALIBRATION FACTOR - K dbuat/m / uv
-16
-15
-14
-13
-12
0
5
10
15
20
25
30
35
40
45
50
FREQUENCY - CYCLES PER SECOND
CALIBRATION CURVE
FOR
ET-1A/SML
SUBAUDIO MAGNETIC LOOP ANTENNA
SERIAL NO. _____

SECTION 3 - OPERATION

3-1 GENERAL

The ET-1A/SML Subaudio Magnetic Loop Antenna and associated units, together with the ET-1A/SA Subaudio Amplifier have been designed to detect magnetic fields in the 3 to 45 cps region of the spectrum. The system is normally utilized in conjunction with a shielded enclosure, but it is not limited to this test setup. The primary requirement is that of a low ambient magnetic field area because of the extreme sensitivity of the equipment. For this reason it may be necessary, when performing tests with this equipment, to shut off all equipment in the test area not directly associated with the test itself, including lighting fixtures. Movement of testing personnel should be held to an absolute minimum during measurement recording.

Using a true rms VTVM, determinations of magnetic fields may be made to well below 32 db above one microampere-turn per meter when the ambient level is not excessive. Using an oscilloscope, frequency determination of the detected signal can also be made to this level in similar conditions.

More precise identification of the detected signal frequency may be made by applying the signal to the oscilloscope as intensity modulation by use of a RASTER GENERATOR, such as the Electro International Model RG-3. This instrumentation enables frequency identification of sine-wave signals at levels significantly below those quoted for magnitude determination.

The Raster Generator, however, will not detect small changes in phase.

3-2 RECOMMENDED ACCESSORY EQUIPMENT

In addition to the ET-1A/SML, Subaudio Magnetic Loop Antenna and the ET-1A/SA, Subaudio Amplifier the following accessory equipments are recommended as required for performing magnetic field measurements.

Instrument	Type	Recommended
Audio Oscillator	3-45 cps range	HP-202C
Audio VTVM	True RMS with 1 mv full scale sensitivity	Fluke 910A
Oscilloscope	Dual trace	Tektronix 516

TABLE 3-1

3-3 EQUIPMENT CONFIGURATION

A typical equipment configuration is shown in figure 3-1. The equipment under test, and the ET-1A/SML, are situated inside the shielded enclosure. The equipment signal source, dual channel oscilloscope, ET-1A/SA, audio oscillator, SML Adapter and VTVM are positioned outside the shielded enclosure.

Signal Connections

One of the 15-foot 5-conductor cables is used to connect the ET-1A/SML antenna inside the enclosure to the bulkhead connector mounted in the enclosure wall. The other 5-conductor cable is used outside the enclosure to connect the bulkhead connector to the SML Adapter.

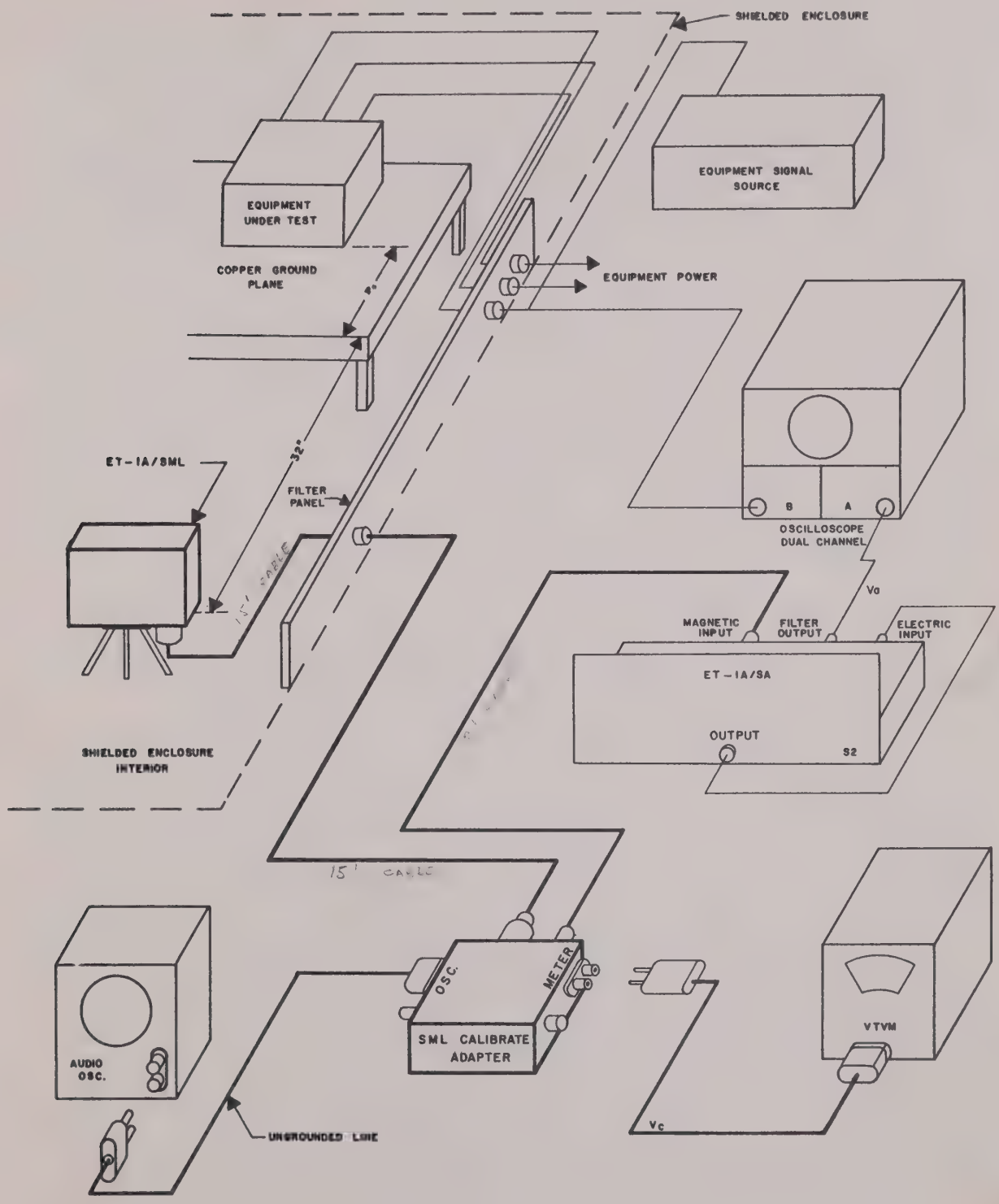


Figure 3-1. Subaudio Magnetic Loop Detection System Equipment Configuration.

A three-foot length of coax is provided for the detected signal path from the SML Adapter to the MAGNETIC INPUT receptacle on the ET-1A/SA Subaudio Amplifier (3-45 cps). The output signal from the Subaudio Amplifier is shown connected to the filter input. The additional filtering is sometimes needed to provide additional attenuation to power-line harmonics (Refer to Section 3-4). The output of the filter is connected to Channel A of the oscilloscope which displays magnetic field signals detected by the ET-1A/SML Loop Antenna. Channel B of the oscilloscope is used to monitor the test signal from the Signal Source.

Test Sample Connections

Connections to the Test Sample from the outside are made through similar connectors that pass through the shielded enclosure.

Signal Substitution Connections

During signal substitution an Audio Oscillator is connected to the OSC IN jack on the SML Adapter. An Audio Oscillator is used as the signal substitution source when sinusoidal waveforms are detected. The calibration voltage is measured with a vacuum tube voltmeter connected to the METER jack on the SML Adapter.

3-4 ET-1A/SA SUBAUDIO AMPLIFIER

The ET-1A Subaudio Amplifier is functionally described in its instruction manual, which should be consulted for detailed information. However, certain connections pertinent to the Magnetic Field Intensity Detection System

will be described here. The ET-1A/SA contains additional 60-cycle notch filters to provide greater attenuation of powerline harmonics in the magnetic field mode of operation. An external connection between OUTPUT and ELECTRIC INPUT is necessary to insert the filters. The signal output is observed at FILTER OUTPUT. With the use of the filters a significant improvement in the sensitivity may be obtained. However, when using these filters in the magnetic mode, the upper 3 db frequency will decrease from 45 to 42 cps.

3-5 TEST PROCEDURES

A. Minimum Discernible Signal

Prior to the start of the test measurements check the M.D.S. of the Subaudio Magnetic Detection System using the following method.

1. Connect the ET-1A/SML to the ET-1A/SA as shown in figure 3-1. Apply ac power to test equipment and allow 30 minute warm-up. Insure, however, that there is no ac power applied within the shielded enclosure.

2. Place Switch S2 of the ET-1A/SA Subaudio Amplifier in the MAGNETIC position. Internal notch filters may be connected for additional 60-cps attenuation (refer to Section 3-4).

3. Observe the output of the Subaudio Amplifier, V_a, with a VTVM and an oscilloscope, and orient the ET-1A/SML antenna for minimum noise output. If the 60-cycle noise is too great, internal notch filters can be connected. Record the ET-1A/SA output, V_a.

4. Apply a test signal at 24 cycles per second to the SML Adapter from the Audio Oscillator, (balanced output). Adjust the test signal amplitude until the ET-1A/SA output reading (V_a) obtained in step 3 has increased 3 db (1.414 times greater). Measure the calibrate voltage amplitude, V_c, at the meter terminals of the SML adapter, and convert to units of db above one microvolt, (dbμv). To determine the M.D.S., add the calibration factor (-14.2 db$\frac{\mu \text{at/m}}{\mu \text{v}}$) corresponding to 24 cps.

$$\text{M.D.S.} \quad V_c \text{ db}\mu\text{v} - 14.2 \text{ db}\frac{\mu \text{at/m}}{\mu \text{v}}$$

5. The minimum discernible signal results in either the sensitivity of the ET-1A/SML in the ambient noise level. If the ambient level is too high to permit use of the full sensitivity of the ET-1A Magnetic Detection System, turn off the ac power to unused equipment and to the lights in the area as far as is practicable, and repeat step 3. Next, re-measure V_c as in step 4, using great care to select an orientation yielding the minimum ambient noise output.

Under certain conditions it may not be possible to reduce the ambient noise to the level of the sensitivity of the ET-1A/SML. In this case the above procedure will result in the Ambient Noise Level and not the sensitivity of the ET-1A/SML.

B. Magnetic Field Intensity Measurements

If the measurement of M.D.S. in 4. above establishes the orientation for minimum ambient noise, then the SML antenna should remain

in this position. However, if the measurement results in the sensitivity of the SML antenna the ambient noise will have no effect on the position of the antenna.

1. In the shielded enclosure, connect the equipment under test, and the ET-1A/SML to the ET-1A/SA as in figure 3-1. Apply power to the test equipment and allow 30 minutes warm-up time for stabilitzation.

2. Provide the equipment under test with its proper input signal and load, as required. (If it is necessary to keep the antenna stationary, then the test sample must be rotated to detect the different directions of possible radiation. For optimum results the axis of the antenna should not point toward the source of the magnetic field).

3. Monitor the signal input to the equipment under test with Channel B of the dual-trace oscilloscope.

4. Observe the output of the Subaudio Amplifier on Channel A of the oscilloscope.

5. Determine the strength of any detected signal by the signal substitution method, as follows:

a. Measure the voltage, V_a, of the detected signal at the output of ET-1A/SA Subaudio Amplifier.

b. Determine the frequency of the detected signal with the oscilloscope, and then remove the signal by turning off the equipment under evaluation.

c. Connect the audio oscillator to the SML Adapter; adjust the oscillator to the frequency of the detected signal and to an output which

will produce a voltage reading at the output of the ET-1A/SA equal to the value (V_a) obtained in step 5-a above.

d. Measure the calibration voltage, V_c, at the meter terminals of the SML Adapter. Convert this reading to db above one microvolt, dbμv.

e. The magnetic field intensity, H, in db above one microampere-turn per meter (db μat/m), is equal to V_c in dbμv plus the calibration factor K in db $\frac{\mu at/m}{\mu v}$

$$H \text{ db}\mu\text{at/m} = \text{db}\mu\text{v} + K \text{ db}\frac{\mu\text{at/m}}{\mu\text{v}}$$

Refer to Figure 2-2 for the calibration factor, K.

3-6 SAMPLE CALCULATIONS

A. Decibels

1. Given: Calibration voltage, V_c, was found to be 400 microvolts.

2. $V_c \text{ db}\mu\text{v} \quad 20 \log \frac{V_1}{V_2}$

where V_1 400 μv
V_2 reference voltage = 1 μv

V_c dbμv = 20 log 400

V_c dbμv = 52 dbμv

B. Minimum Discernable Signal (Internal notch filter used)

1. Given: Minimum output of ET-1A, V_a, is 14 mv

2. 3 db above 14 mv is 19.5 mv.

3. To obtain V_a = 19.5 mv, V_c .4 mv 52 dbμv

4. M.D.S. = V_c -14.2 db $\frac{\mu at/m}{\mu v}$

= 52 dbμv - 14.2 db $\frac{\mu at/m}{\mu v}$

= 37.8 dbμat/m

C. Narrowband Signals

1. Given: Detected signal output, V_a = 210 mv at 30 cps.

2. To obtain V_a = 210 mv, V_c is equal to 16 mv at 30 cps.

(With equipment under test - OFF).

3. 16 mv = 84.1 $db_{\mu}v$

4. H $V_c + K$

H 84.1 $db_{\mu}v$ - 13.9 $db \frac{\mu at/m}{\mu v}$

H 70.2 $db_{\mu}at/m$

SECTION 4 - MAINTENANCE

4-1 SERVICING

The magnetic antenna of the ET-1A/SML is sealed at the factory and requires no maintenance.

4-2 PARTS LIST

Symbol Design	Description	Manufacturer's Part Number
	Subaudio Magnetic Loop Antenna	ET-1A/SML
	Subaudio Magnetic Loop Adapter	ET-1A/SML Adapter
W1	Assembly cable, 15 feet, 5-conductor shielded	
W2	Assembly cable, 15 feet, 5-conductor shielded	
W3	Instrument cable, 3 feet	RG-59B/U
W4	Instrument cable, 3 feet	RG-59B/U
	Bulkhead Feedthru	TBF-14S-6PS
R1	Resistor 100 ohms	
C1	Capacitor .1 μf	
J1	Connector	MS 3102A-14S-6S
J2	BNC Connector	UG-1094/U
J3	BNC Connector	UG-1094/U
J4	Double Banana Jack	GC 33-290
J5	Connector	MS 3102A-14S-6P
J6	Double Banana Jack	GC 33-290

Symbol Design	Description	Manufacturer's Part Number
P1	BNC Connector	UG-260A/U
P2	Connector	MS 3106A-14S-6S
P3	Connector	MS 3106A-14S-6P
P4	Double Banana Plug	Palma MDP
P5	Double Banana Plug	Palma MDP
P6	Double Banana Plug	Palma MDP
P7	Double Banana Plug	Palma MDP
P8	Connector	MS 3106A-14S-6S
P9	Connector	MS 3106A-14S-6P

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